Buried Evidence

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Figure 1 – photograph of the study site, with the grassy bank on the left several metres higher than the natural ground height (background). Adapted from Ruffell et al. (2018).

Dr Alastair Ruffell and **Dr Jamie Pringle** explain how applied geophysics can be used to assist in environmental crime investigations.

Buried evidence

Buried illegal waste and uncontrolled legal waste dumps are a major problem throughout the world, both in developing and more economically developed countries. However, criminal police investigations could use geoscience to assist in better understanding how to locate and characterise such waste.

Waste sites are also commonly associated with the disposal of criminal items, including stolen vehicles, materials used in crimes as well as victims of homicide. This collaborative report details how applied geoscientists from Queen's University Belfast and Keele University assisted one such investigation in Northern Ireland to support an eventual criminal conviction.

The environmental and economic costs are as equally significant as the political background as to why waste is buried in the first place. Why bury rubbish? Because it is easy to do and the perpetrators can make money from 'recycling', whereas in fact, it is often dumped. As the old saying goes, 'there is cash in trash, there is brass in muck'.

The problem of illegally-buried waste may then result in criminal proceedings against the landowner and/or supposed perpetrator. In a court of law, the nature of the waste (its content, specifically toxicity), volume, effect on the environment and location (on the owner's land or not) all have to be taken into consideration, as these will determine the sentence (financial penalty and/or prison term) that may be applied, if a guilty verdict is passed.

The general problem in such cases is that once buried illegal waste has been identified, test-pits dug and criminal cases brought by the environmental law enforcement agencies, in the subsequent criminal court case, while the magnitude of the crime in terms of illegal burial and perhaps groundwater damage has been established, the volume of waste is under contention. This will determine the severity of the sentence in the UK.

In our experience, often the prosecution will argue that extrapolating the subsurface extent of waste from test-pits provides an estimate of buried waste volume.

The defence may then counter-argue that these test-pits are not representative, and may be hitting pockets of deeper waste, or were statistically not significant, and thus the accused is only guilty of a lesser crime (burial of minor amounts of waste).

In addition, the defence in these situations are sowing the seed of doubt in the minds of the court and jury that environmental law enforcement officers and the prosecution's case are flawed.

Well-informed environmental law officers have realised that applied geoscience can provide a more complete picture of the volume and possible makeup of buried waste.

To make a reasonable assessment of waste volume, the waste extents needs to be both topographically surveyed and its thickness determined – usually by geophysics – to quantify the volume and hence severity for the courts.

Surveying can also assist in the question of whether the physical waste and/or its liquid leachate extend beyond the owner's land that is being investigated.

We now provide an example.

Law enforcement officers in Northern Ireland wished to

Figure 2 – differential GPS topographic survey, with red flags/dotted line indicating where the High Water Mark line should be, critical here in that this caused an additional prosecution due to different land owners (see text). Modified from Ruffell et al. (2018).

have geoscience assistance on two sites next to a river and estuary in Northern Ireland. An initial desk study showed that the bedrock was sedimentary 2m to 10m below ground level, with the overlying coastal glacial and river-derived sands and gravels forming the soils. Historical maps showed the original land surface to be different from that observed on a reconnaissance visit, with part of it in a SSSI (site of special scientific interest) and should form part of a river (Figure 1).

An accurate differential GPS (Global Positioning System) topographic survey was then undertaken (20mm accuracy), mapping out where the raised artificial areas were on both

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Areas and where the river/coast should have been (Figure 2), as waters come under separate jurisdiction, being Crown Estate land, and thus a far more serious legal infringement. Results found Area A to have 10,000 sq m and Area B to have 11,000 sq m of waste extents.

A near-surface geophysical survey was then collected, with a series of 2D electrical resistivity and GPR (Ground Penetrating Radar) profiles collected across the survey sites, in order to quantify the waste thickness.

After data processing and interpretation, it was observed that in Area A, illegal waste was placed directly over the coastal salt marsh, with the saline soil making the GPR data relatively poor, albeit a good target for electrical resistivity surveys (Figure 3).

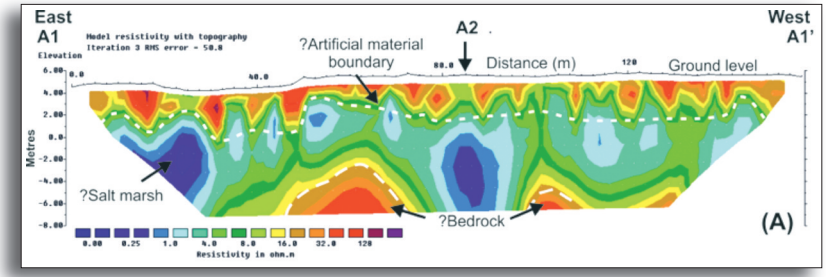

Figure 3 – electrical resistivity 2D profile acquired over Area A, with interpreted illegal waste depths, original salt marsh position and bedrock indicated. Modified from Ruffell et al. (2018).

For both sites, there was calculated to be averaging 2m to 4m in thickness of illegal waste present.

Combining these datasets allowed total waste volumes of almost 38,000 cubic metres and 40,000 cubic metres for Areas A and B respectively, which equated to a total clean-up cost of more than £250,000.

A subsequent scientific report was generated and forwarded to the Crown Prosecution Service as evidential material for prosecution purposes which, due to the complexity of the case, resulted in eventual criminal convictions in both cases.

An unforeseen consequence of this study was some two years later, when police officers contacted the authors – they were searching the same land for a vehicle that was used to transport a murder victim.

While our survey was limited in areal extent, we had surveyed just such an item, and were able to provide police with its location.

In addition, we had invaluable information on the depth to bedrock and nature of the landfill, such that the police

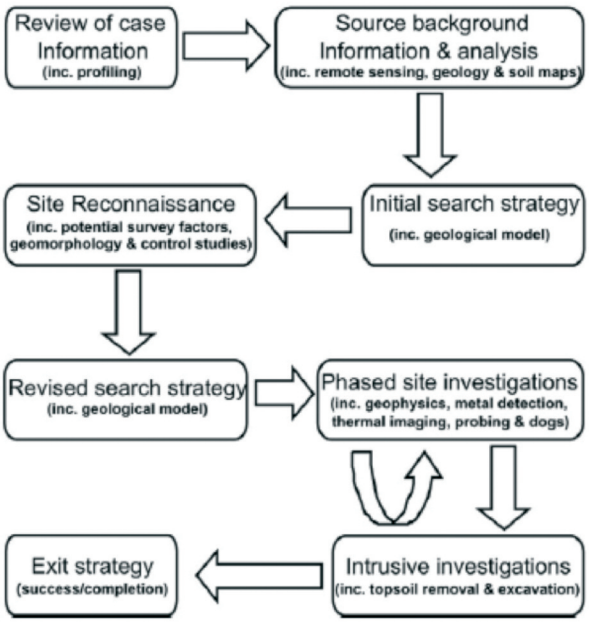

Figure 4 – generalised workflow for search, not taken into account target size, type and time since burial, background soil type, etc. Modified from Pringle et al. (2012).

search team was not digging 'blind' but had a comprehensive reconnaissance study as the search progressed.

This article has highlighted how applied geoscience can assist in criminal investigations of illegally dumped or uncontrolled waste, in this case providing scientific evidence of both extent and thickness to give volume estimates that were relied upon in a court of law.

Intrusive investigations (trial pits and/or boreholes) on targeted geophysical anomalies can also further validate results if required.

A workflow is provided in Figure 4. Rapid geoscience surveys can assist police forces on active investigations to both gain scientific evidence for prosecutions and to potentially deter future environmental crime.

Using multiple institutions in this case also utilised the complementary skills of different researchers effectively and gave confidence in the evidence presented in court. PP